Oxygen Enhanced Combustion for NOx Control

Lawrence E. Bool III, Presenter
Praxair, Inc., 175 E. Park Drive, P.O. Box 44, Tonawanda, NY 14150
E-mail: **lawrence_bool@praxair.com**; Telephone: (716) 879-7123; Fax: (716) 879-7275

Hisashi Kobayashi, Co-author
Praxair, Inc., 39 Old Ridgebury Rd, Danbury, CT 06810
E-mail: **sho_kobayashi@praxair.com**; Telephone: (203) 837-2652; Fax (203) 837-2549

Summary

Conventional wisdom says adding oxygen to a combustion system enhances product throughput, system efficiency, and, unless special care is taken, increases NOx emissions. This increase in NOx emissions is typically due to elevated flame temperatures associated with oxygen use leading to added thermal NOx formation. Innovative low flame temperature oxy-fuel burner designs have been developed and commercialized to minimize both thermal and fuel NOx formation. However, at the current cost of oxygen, it is not economically feasible to use 100% oxy-fuel combustion for boilers.

As part of a Department of Energy Cooperative Agreement Praxair and its partners have developed a novel oxygen based technology that can reduce NOx emissions from nitrogen containing fuels, including pulverized coal, while improving combustion characteristics such as LOI. This novel technology replaces a small fraction of the combustion air as part of the process. Conventional oxy-fuel knowledge would indicate that even this small replacement will have a beneficial impact on boiler performance independent of any reduction in NOx.

The development program for this technology began with experimental work performed at the University of Arizona. These experiments used the small-scale (17 kW) downfired combustor to validate the concept with two different samples of the Illinois No. 6 coal. Several problems with the system lead to inconclusive results, although in general the results were promising. Additional testing was then performed at the L1500 facility at the University of Utah. This facility is a refractory lined horizontal furnace fired at 4 MMBtu/h. Three different bituminous coals were tested as part of this work, an Illinois No. 6, an Illinois No. 5, and a Utah bituminous coal. This work included general flue gas sampling and detailed furnace mapping. Data from this facility and these three coals served to better define the technology and guide larger-scale work proposed as part of the program.

Throughout the program a combination of CFD modeling from Reaction Engineering International (REI) and Praxair proprietary kinetic models were used to supplement and guide these experimental efforts. The kinetic modeling was used better understand the results from the University of Arizona and to better define the potential of the technology. The CFD modeling focused on the L1500 furnace and was used to interpret the results from that furnace and guide additional experimentation. REI's existing boiler models are also being used to test new facets of the technology.

Encouraging results from both the modeling and the experiments led to testing at a commercial scale. These large scale tests utilized Alstom Power's ISBF, 24 MMBtu/h, facility fired with an off the shelf Alstom burner. The ISBF facility is designed to mimic the time-temperature histories typical of conventional utility boilers. Three different coals were tested in this facility, including two bituminous coals and a PRB coal. Results from these, and earlier tests in the program, were used to better define the economics of implementing the technology. Test results from the tests will be presented and relative economic performance discussed.